GRACE Project: model-based control of a nonlinear actuator

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Published in:
Benelux Meeting of Systems and Control

Publication date:
2019

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1 Introduction

Natural phenomena have proven to be a great source of inspiration for developing specialized devices. Insect compound eyes offer promising insights for the development of new artificial navigation and vision systems [5]. In recent years, a Goniometric Research Apparatus for Compound Eyes (GRACE) has been developed. The aim of the apparatus is to obtain a rapid mapping of compound eyes. Initially a non-automatized system was used [4], [5]. The apparatus has been automatized into a specialized mechatronical device with 6 degrees of freedom, with an upper and lower optical stage and a digital camera (Figure 1). In the last upgrade an auto-focusing algorithm sets the position of the studied insect using the sharpness of the image by controlling the position of Motor Z. Motors X and Y adjust the lateral position, depending on the image details. To control the position of the camera system, which is attached to a Zeiss microscope in the upper stage, a highly nonlinear actuator for a Elero DC motor has been developed. The actuator holds the microscope, which, due to a lead screw, is severely affected by gravity and a high friction coefficient. An energy-based model is here applied using the port-Hamiltonian framework (pH), taking the mass of the system in the screw as an external force, and based on the self-locking property [1]. An optical rotational encoder is the sensor used in the actuator. The proposed controller is a dynamical extension based on the results of [2]. Experimental results can be obtained with a longitudinal accuracy of the microscope position of 5 m. The developed GRACE system allows the massive collection of detailed images of insect eyes, i.e. of flies and butterflies.

2 Experimental setup

The GRACE system is shown in Figure 1. First, the M axis is in repose when the DC motor is not powered. The aforementioned is due to the motion transformation mechanism, a lead screw presents a nonlinear behavior, dependant of the direction of motion and friction. The above is considered as an external force entering the rotational system.

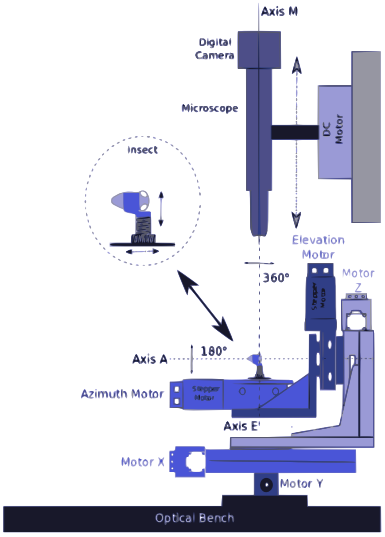

Figure 1: Schematics of the GRACE system at University of Groningen [3].

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